Pluto-Kuiper Express Mock-up Spacecraft

Acoustic Test Results

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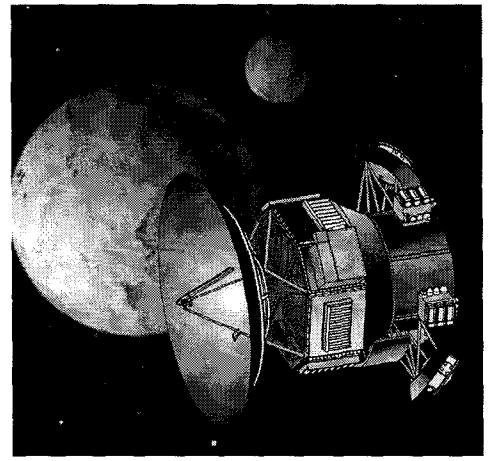

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INTRODUCTION TO PKE ACOUSTIC TEST

- Pluto-Kuiper Express (PKE) spacecraft mission to explore Pluto
  - 400- 450 kg spacecraft with Radioisotope Thermal Generator (RTG)
  - Atlas V or Delta IV/ Star 48 launch with 8-10 year flight time
  - Galileo heritage RTG
  - Mission cost constraints precluded RTG re-qualification
- Acoustic testing performed on various configurations of the PKE mock-up spacecraft
  - Protoflight (PF) acoustic specification, 143.7 dB overall
  - JPL D-19440, 'Pluto-Kuiper Express Mock-up Acoustic Test Plan'
- Testing accomplished in JPL's 10,000 ft^3 reverberant acoustic chamber, August 14 to August 29, 2000

PKE ACOUSTIC TEST OBJECTIVES

- Primary test program objectives:
  - Compare PKE RTG random vibration environment with heritage Galileo RTG specification
  - Evaluate the relative effects of three RTG mounting schemes on RTG random vibration environment
- Secondary test program objectives:
  - Evaluate the relative effects of bus panel construction and equipment mass loadings on bus panel random vibration response
  - Evaluate the relative effects of equipment mass loading on the bus panel random vibration response
  - Evaluation of vibroacoustic analysis software and modeling techniques for prediction of RTG and bus panel random vibration response

PKE ACOUSTIC TEST CONFIGURATIONS

- Baseline test article consisted of mock-up PKE spacecraft in launch configuration with X-mas tree RTG mount and flat HGA simulator
- PKE mock-up spacecraft tested with three different RTG structural mounting schemes
  - X-mas tree RTG mount bolted to closeout panel
  - X-mas tree RTG mount raised off closeout panel by set of spacers
  - Strut RTG mount
- PKE with two different RTG mounts, with and without flat HGA simulator
  - X-mas tree RTG mount bolted to closeout panel
  - Strut RTG mount

PKE DYNAMIC INSTRUMENTATION

- Dynamic instrumentation; control and monitor microphones in 4 pairs (8 mics)
  - Located around mock-up spacecraft at least 24 inches from any surface
- Forty-three piezoelectric accelerometers bonded to the spacecraft with a cyanoacrylate ester type adhesive (Eastman 910)
- Color photographs taken of the overall acoustic test configuration and close-ups of the instrumentation
- Four Kistler 9251A three-axis force gages utilized to measure interface forces at the base of the CET model RTG
  - Twelve force channels summed to X, Y and Z axis total force signals

PKE ACOUSTIC TEST CONTROL AND DATA

- Controlled spectral average of 4 control microphones located around the test article
- Nominal test duration 60 seconds, minimum of 40 seconds steady-state exposure
- Microphone data reduced to 5 Hz narrow band and 1/3 octave band sound pressure levels (SPL) from 20 Hz to 10 kHz
- Accelerometer data reduced in 5 Hz narrow band power spectral density values (g^2/Hz) from 20 Hz to 2 kHz

PKE Mock-Up Acoustic Test Levels and Tolerances (Test Duration: 60 sec.)

1/3 Octave Band Center Frequency (Hz)	Sound Pressure Levels, dB (ref. 20 μPa)		Test Tolerances, dB (ref. 20 μPa)
	PKE	EUROPA	
31.5	130.5	132.0	+5, -3
40	131.5	133.5	+5, -3
50	132.5	134.5	+5, -3
63	133.0	135.5	± 3
80	133.5	136.0	± 3
100	133.5	136.0	± 3
125	133.5	136.0	± 3
160	133.5	135.5	± 3
200	132.5	134.8	± 3
250	132.0	134.0	± 3
315	131.0	133.2	± 3
400	130.0	131.8	±3
500	128.5	130.5	± 3
630	127.5	129.2	± 3
800	126.0	127.3	± 3
1000	124.5	125.5	± 3
1250	123.0	123.7	± 3
1600	121.0	121.3	± 3
2000	119.5	119.5	± 3
2500	118.0	118.0	± 3
3150	116.0	116.0	± 3
4000	114.5	114.5	± 3
5000	112.5	112.5	± 3
6300	110.5	110.5	± 3
8000	109.0	109.0	± 3
10000	107.0	107.0	± 3
Overall	143.7	145.8	±1

PKE Mock-up Acoustic Test Accelerometer Locations

Designation	Location
A1X	CET Top, +X Side
A2Y	
A3Z	
A4X	CET Middle, +X Side
A5Y	
A6Z	
A7X	CET Adapter Bottom
A8Y	
A9Z	
A10X	CET Adapter Top
A11Y	
A12Z	
A13X	Top Closeout Panel, -X +Y Corner
A14Y	
A15Z	
A16X	Top Closeout Panel, +X -Y Corner
A17Y	
A18Z	
A19Z	Top Closeout Panel, near center
A20X	Tank, top edge
A21Y	
A22Z	
A23Z	Tank, bottom interface
A24X	Bus Interface, bottom +X +Y corner
A25Y	
A26Z	
A27Y	HGA Panel, center
A28X	HGA to Bipod interface, +X +Y middle
A29Y	
A30Z	
A31X	HGA, center
A32Y	
A33Z	
A34Y	Bipod to HGA interface, +X +Y middle
A35X	Science/ACS Panel, middle, near corner of mass simulator 1.1
A36Y	
A37Z	
A38X	Science/ACS Panel, near top edge of mass simulator 1.3
A39X	Science/ACS Panel, near –Y edge of mass simulator 1.1
A40Y	Telecom Panel, near +X edge of mass simulator 2
A41Y	Telecom Panel, middle of upper panel area
A42X	C&DH/Power Panel, near -Y edge of mass simulator 3
A43X	C&DH/Power Panel, middle of upper panel area

RTG CET DATA EVALUATION

- RTG CET random vibration exceeded heritage PF Galileo RTG specifications for all RTG mounting configurations
  - Response in the Y axis (cantilever mode) was most severe
  - 1.6 g2/Hz at 170 Hz; specification level of 0.1 g2/Hz
  - Exceeded the specification by more than 12 dB
- PKE baseline RTG mount had lowest peak RTG random vibration response
  - Exceeded Galileo RTG specifications in lateral axes, 100 to 220 Hz
- RTG CET interface force data also indicated that baseline mount had significantly lower responses than truss mount design

RTG CET DATA EVALUATION, Continued

- Truss mount and X-mas tree frame mount on spacers decreased lateral stiffness of the RTG mount causing higher response compared to the baseline
- RTG CET random vibration response without the flat HGA simulator 5 dB lower than same configuration with the simulator installed, 100 to 300 Hz
  - Still exceeded PF Galileo RTG specification in the Y axis, 100 to 220 Hz
  - RTG CET interface forces were significantly reduced
- Data indicated HGA is main driver of PKE bus vibration in all three directions
- Flight spacecraft design changes and installation of actual HGA could significantly alter RTG vibration

PKE Bus Panel Data Evaluation

- Science/ACS Panel, Telecom panel and C&DH/ Power panel vibration response compared to:
  - PKE random vibration specifications for baseline spacecraft configuration
  - PKE random vibration also compared with SEA random vibration predictions
- PKE equipment specifications and SEA predictions were exceeded by mass mockup vibration inputs in every zone
  - Response levels reached 4.25 g2/Hz at the Telecom panel
  - Unloaded regions of bus panels as high as 40.0 g2/Hz
  - Vibration response trend correlated with overall supported mass on panel
- Panel interface vibration expected to be less severe with actual spacecraft equipment in place of mass mock ups
  - Probably would result in better agreement with SEA predictions

PKE Acoustic Test Conclusions

- RTG CET random vibration exceeded PF Galileo RTG specifications for all RTG mounting and spacecraft configurations, especially in the lateral axis
- PKE baseline configuration had lowest peak RTG random vibration response except for the following:
- RTG CET random vibration without the flat HGA simulator was 5 dB lower than configurations with the simulator installed
- PKE equipment specifications and SEA predictions were exceeded by mass mockup vibration inputs in every zone
- Interface vibration probably less severe with flight equipment installed (leading to better agreement with SEA predictions)
- Flight spacecraft design changes and installation of actual hardware could significantly alter RTG vibration

Figure 1. PKE CET Test Configuration Baseline

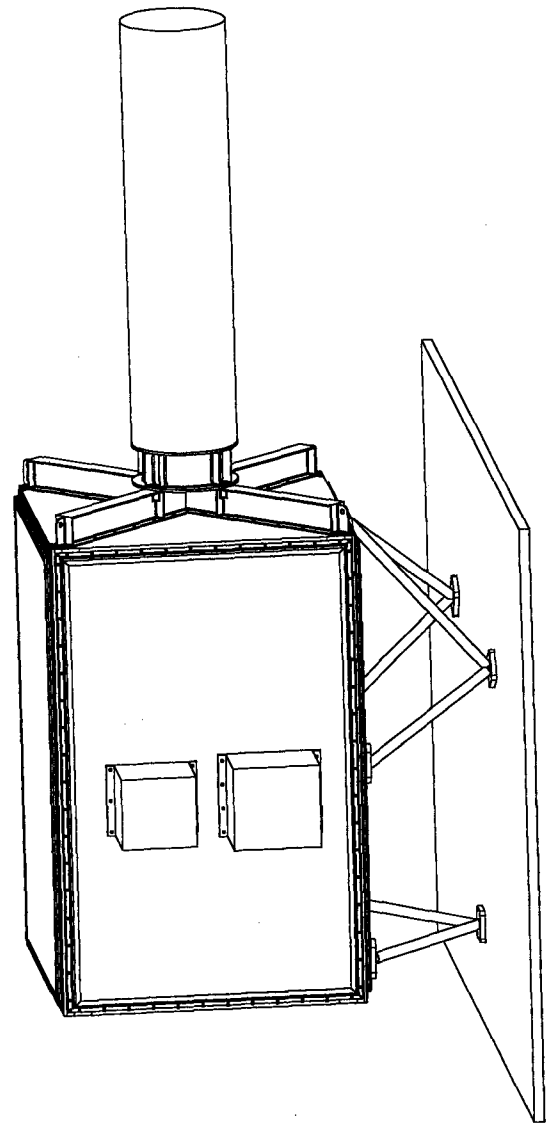


Figure 2. PKE Test Configuration Without HGA Plate

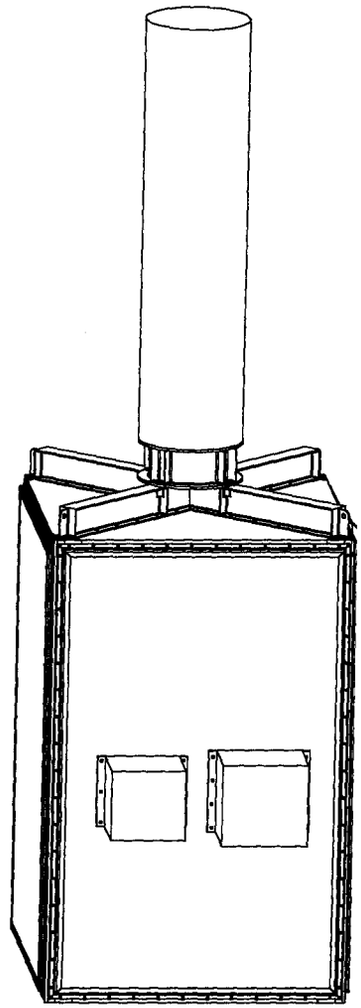


Figure 3. RTG CET Test Configuration With Spacer Under Mount

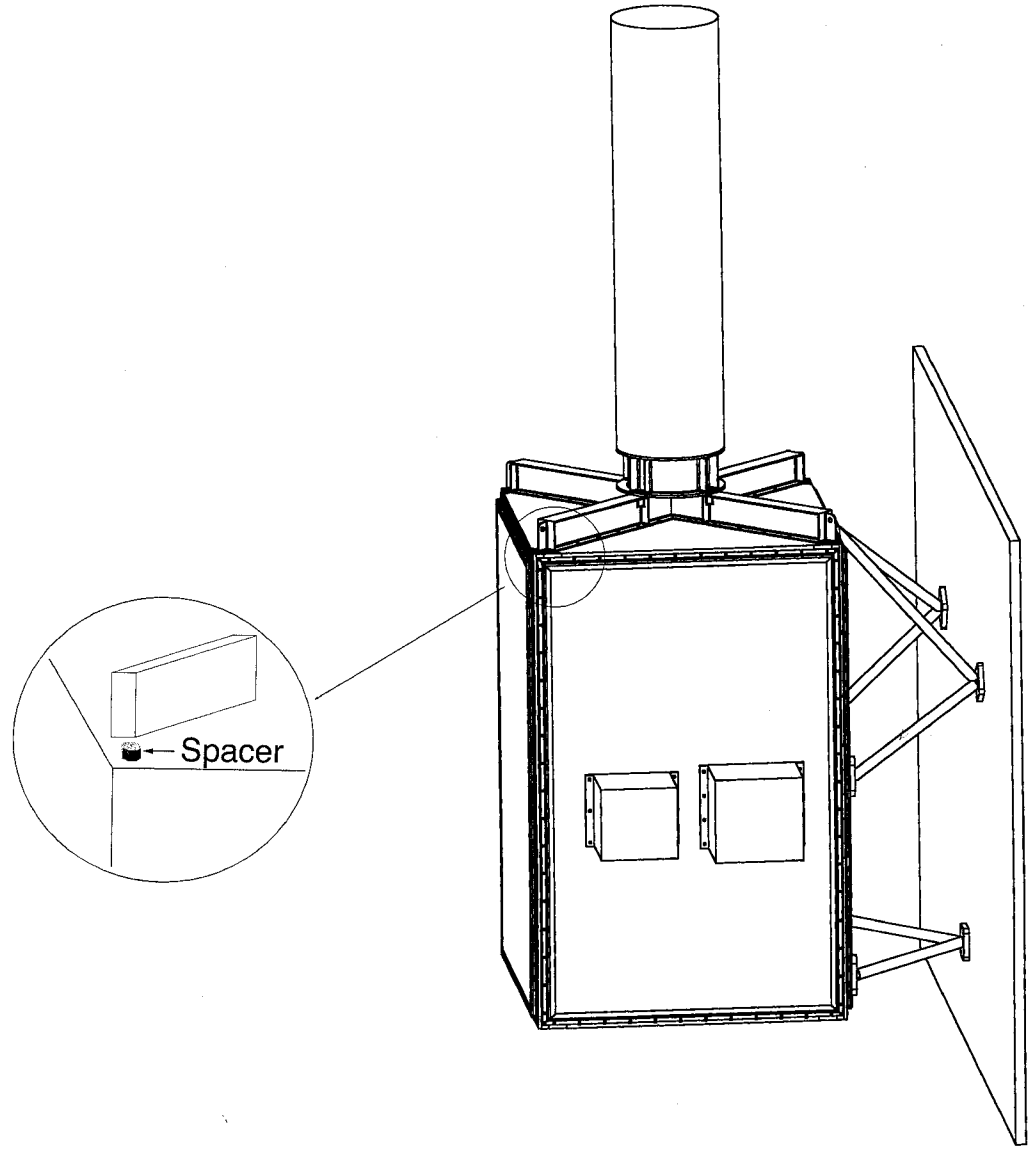
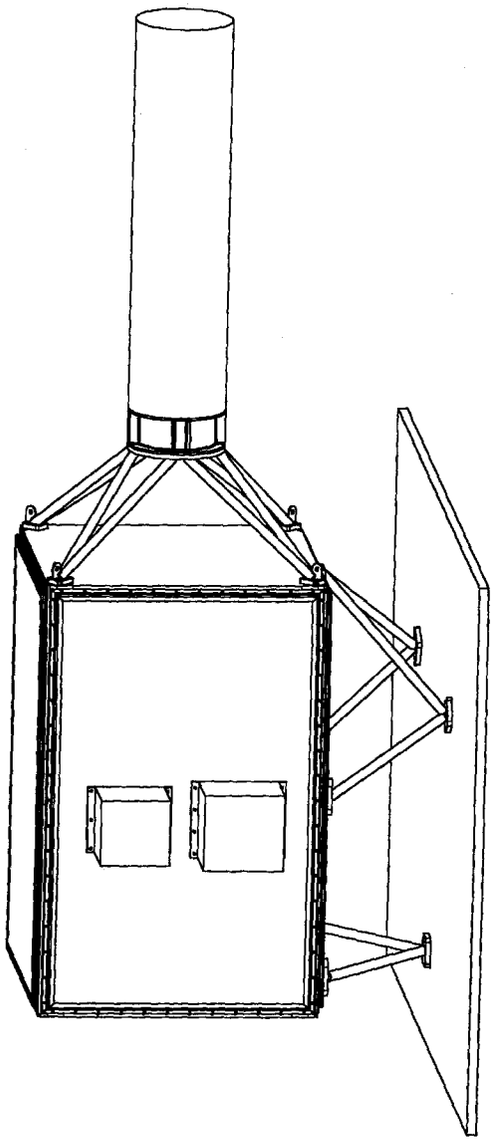


Figure 4. Test PKE RTG CET Truss Configuration



Protoflight Acoustic Test Levels for PKE Mock-up